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The 10 most important business developments
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It wasn't the first time semiconductors created or destroyed an industry, and it wouldn't be the last, but the timing in 1975 was impossibly exquisite. That January the first personal computer—the MITS Altair 8800—appeared on the cover of Popular Electronics. Later in the same year, Keuffel & Esser, the largest manufacturer of slide rules in the United States, produced its last slipstick.

At the time, electronics were becoming commonplace but the modern semiconductor-based electronics industry was still in its infancy. Microprocessors had been available for only four years. Gordon Moore's famous prediction was only 10 years old. Integrated circuits had been kicking around for just over 15 years.

Since then, the electronics industry has matured and changed. Most of the original giants are still around, but now they compete with and rely on a sea of more specialized companies up and down the supply chain and across the world. Transistor sizes have plummeted, but manufacturing costs have risen, forcing businesses to rethink how they design and build products.

Distilling that colorful history into 10 discrete business developments turned out to be a significant challenge. But the electronics industry has never hesitated to forge ahead in the face of uncertainty, and, in that spirit, we present, in roughly chronological order, the 10 most significant business developments of the last 30 years.

Desktop PC
The MITS Altair 8800 can lay claim to being the first personal computer, and the Apple II drove the popularity of the personal computer, but the 1981 debut of the IBM PC gave the electronics industry the platform to grow on.

The original packaging for the IBM personal computer

Perhaps most importantly, the IBM PC architecture fueled billions of dollars of demand, kick-starting the young industry. Businesses that wanted to purchase personal computers but were put off by Apple's soft image and lack of history could now buy a system either made by or guaranteed to be compatible with systems from the granddaddy of business computing. Requiring neither exotic manufacturing technology (at first) nor advanced design skills, the eminently (and intentionally) clonable IBM architecture caught on quickly. "A big part of our business at LSI Logic was building chip sets for the cloners," recalls Rob Walker, cofounder of LSI Logic, which was one of the first ASIC design and manufacturing companies. A few years later, the U.S. government made the IBM PC-compatible its standard desktop platform, cementing the market for millions of systems.

In addition to the sheer volume of components required, increasingly complex operating systems and software would push the electronics industry to produce products that were ever more capable. As it turned out, the PC architecture proved to be an ideal environment into which the growing semiconductor industry could funnel its latest technology. The design could accommodate individual advances in processor, memory or chip sets, allowing each area to advance as rapidly as possible. "The IBM architecture played perfectly into the semiconductor's scalability," says Bob Merritt, vice president of DRAM for research firm Semico.

The Rise of Japan

From the beginning of the semiconductor electronics industry, U.S.-based chip makers dominated the world business. That changed in the early 1980s, when dedicated efforts by Japanese chip makers bore fruit. By 1982 Japanese companies had captured 33 percent of the world semiconductor market. That percentage grew steadily—largely at the expense of U.S. manufacturers—and peaked in 1988 (see the chart "World Semiconductor Market Shares," below).

Japan's entry into the world market also changed the rules of the game, reinforcing the boom-and-bust cycles that have become a fixture of the semiconductor scene. Responding to the popularity of the personal computer, several Japanese companies teed up a series of large fabs dedicated to producing DRAM. By 1981 the competition was vicious, and RAM prices dropped by 80 percent. "Nobody had experienced bringing those big fabs online and running them full-out," says Sherri Garber, senior vice president of Semico.

The first oversupply happened in 1981, but it wasn't the last. The bottom dropped out again in 1985, leading to a great deal of trade friction between the U.S. and Japan, as U.S. manufacturers accused the Japanese companies of selling components below the cost of production. "The charges against Japan were ludicrous," says one industry veteran, who prefers to remain anonymous, but they also reflected the mood of the country when it seemed as if U.S. companies could do nothing right. The era of Japan's rise marked the political awakening of the U.S. semiconductor industry and the rise to prominence of industry associations such as the Semiconductor Industry Alliance (SIA).

The Quality Revolution

The debut of the Japanese RAM manufacturers also uncovered a dirty little secret in the U.S. chip industry: Few companies were focusing on chip quality in any sort of systematic way. Total volumes were low enough, the equipment was inexpensive enough and the design process was primitive enough that nobody expected everything to work correctly every time. "Coming out of the 1970s, yields were really poor," says Dan Hutcheson, principal analyst with VLSI Research, but nobody really thought it was much of a problem. "If you tested a chip and it failed, you simply didn't ship it."

But that didn't fly for the Japanese chip makers, steeped in the kaizen quality mentality, inherited from the auto industry. And once customers started comparing chip performance, it didn't fly for U.S. manufacturers either. The turning point came when Hewlett-Packard publicly stated at an industry conference in 1980 that Japanese companies were producing higher-quality chips than U.S. firms.

The competitive pressure sparked a surge of quality initiatives throughout the U.S. chip industry, all based on statistical process control and the concepts of continuous improvement pioneered by W. Edwards Deming: Six Sigma at Motorola; Copy Exactly at Intel; and Total Quality Management, which was first introduced by the U.S. Department of the Navy. It also provided a jump start for the field of yield management, which turned out to be perfect timing for a pair of companies founded in 1976: KLA and Tencor.

Globalization

Globalization starts with sending manufacturing offshore to less technologically advanced areas to take advantage of low labor costs. As the local economy grows, demand develops for the electronics products that the increasingly sophisticated—and better-paid—workforce is assembling. As the workforce grows more sophisticated, it can take on more-complex tasks, including management and product design.

It's a virtuous cycle that has shaped the electronics industry for the last 30 years. According to the American Electronics Association, 60 percent of U.S. high-tech companies received more than half their revenue from non-U.S. markets in 2003. "Globalization shifted the industry to a 24x7 way of thinking; the sun never sets on a global business," says Hutcheson. In addition to developing new markets, companies with far-flung offices, suppliers and customers drive demand for communications and computing technology. "Eventually, globalization is going to change the way semiconductors are designed," says Merritt. "A lot of the definition of future products is shifting toward the Asia-Pacific markets." (To read more about the effects of globalization on the electronics industry, see our October supplement, "Think You're Already Global?")

Foundries
Looking for an infallible harbinger of change? Pay attention anytime somebody purports to say what "real men" do, and then go the opposite way. "Real men have fabs," said Jerry Sanders, then CEO of 1980s-vintage Advanced Micro Devices (AMD). Jump-cut to 2004, when nine out of the top 10 fabless semiconductor companies posted revenue exceeding $1 billion and nearly every IDM outsources some of its production to a pure-play foundry. According to the Fabless Semiconductor Association, foundries accounted for 16 percent of worldwide IC sales in 2004 (see the chart "Growing Fabless Revenue," below).

At times it seems as if Taiwan Semiconductor Manufacturing Company (TSMC), Chartered Semiconductor Manufacturing, United Microelectronics Corp. (UMC) Group and the fast-growing Shanghai-based firm Semiconductor Manufacturing International Corp. (SMIC) have the industry hanging on their every syllable; some observers predict that the foundries' share of the semiconductor market could grow to 50 percent. But not everyone is so sure. Scott Jones, president of research firm IC Knowledge, suggests that the inherent disadvantages of not being an IDM may catch up with the pure-play foundries. He believes that semiconductor design is becoming so tightly linked to process that it's difficult to get high yields quickly unless you own the production line. Jones also suggests that picking up IDM overcapacity puts foundries in a vulnerable position. "When things get slow, the IDMs pull production back in house," says Jones. "It's great for the large manufacturers but not so great for the foundries."

Increasing Design and Production Costs
Call it the brutal, grinding side of Moore's Law. Says Semico analyst Dave Cavanaugh, "It's a problem we've been struggling with for years: What is the total cost for getting a chip from concept to production?"

The short answer: it's getting high and getting higher. Mask sets have become larger and more expensive at each process node—a result of more layers, more-expensive tools and the monstrous basic physics problems following the industry's shift to subwavelength lithography in the mid-1980s. "The paintbrush got bigger than the lines we're trying to paint," says Cavanaugh. But that's only part of the problem. Chip design has become exponentially more complicated. DFM and EDA can help, but software toolmakers must walk a tightrope between enforcing manufacturing rules and giving the designer the freedom to create the necessary logic.

How much does it cost to turn an idea into a chip? At the 65-nanometer node, don't come to the party unless you've got $20 million for design and another couple million for masks. For a low-volume application, it may soon be impossible to amortize those costs. Says Cavanaugh, "These days, if you're going to spin an ASIC, you'd better be darned sure you've got a hit."

China

The next time you're at a loss for a topic of conversation at an industry cocktail party, rest easy: Electronic Business has you covered. Just mention China; step back; and watch the execs pull out superlatives, expletives and even possibly their hair.

For electronics companies, China is an enormous challenge and an enormous opportunity. The rule of law there is not yet a settled thing, and IP protections are still unreliable. Chinese semiconductor companies enjoy spectacular tax breaks. Also, the Chinese government has a disconcerting habit of mandating technology standards that don't quite line up with the rest of the world's.

But the demand numbers are staggering. IC Insights recently forecast that the domestic IC market in China will hit $34.3 billion in 2005, larger than both the Japan and Americas markets. Just in case you were stifling a yawn, pay attention. In 2001 the Chinese IC market was only a third the size of the Americas market. The prospects are there—the question is how many companies will be able to catch the tail of the dragon.

Global Supply Chain
The semiconductor supply chain has lengthened by about a hundred links since the early days of the industry. Although there are still several large IDMs that command large swaths of market share, they are outnumbered by an increasing crowd of companies focusing on the part of the process where they can bring value.

Many times, that value can be more about timely delivery than about technology. Why? Because of two catchphrases the industry now lives by: just-in-time manufacturing (JIT) and vendor-managed inventory (VMI). "You put your product in [the customers'] warehouse at your expense," says Brian Halla, CEO of National Semiconductor. "Logistics are more important than the product; that's different from the old days."

Focus is good, but both VMI and JIT have forced semiconductor suppliers to assume more risk by taking responsibility for components until the moment they're needed. These days, semi companies also have to battle customers that are much more savvy about playing suppliers off each other to squeeze out the lowest price. "Procurement used to be the lowest department on the totem pole," says Hutcheson. "Now it's the highest."

Environmental Awareness
Knowing what we know now, the stories are terrifying. "I used to clean the grease off my hands with TCE [cleaning chemical trichloroethylene] and go eat my sandwich," says Stan Myers, President and CEO of the trade group SEMI. The wakeup call came in the mid-1980s, when several industry leaders, including Fairchild Semiconductor and IBM, ended up on the business end of a series of lawsuits. Santa Clara County, California, still has more U.S. Environmental Protection Agency (EPA) Superfund cleanup sites than any other county in the country, and the EPA estimates that by 2004, the cleanup there had cost semiconductor companies more than $200 million.

Lesson learned. Most major semiconductor companies based in Japan, Europe and the U.S. now go out of their way to maintain high environmental standards. Several major manufacturers have launched an Electronics Industry Code of Conduct, and industry associations are working with world governments to firm up regulations. Some of that is due to conscience, but the threat of lawsuits and investor backlash is a powerful incentive.

The pressure to be eco-friendly isn't likely to subside anytime soon. In February 2004, IBM won a lawsuit that alleged that the company knowingly exposed two workers to dangerous chemicals, but more than 200 additional similar lawsuits have yet to go to trial. (For more coverage of the semiconductor industry's efforts to be ecologically responsible, see the June 2005 supplement "How Green Is the Valley?")

Sarbanes/Oxley

SSome have called the Sarbanes-Oxley Act (SOX) the biggest rule change for U.S. business since the Securities Exchange Act of 1934. Observers say that it has affected everything from corporate bottom lines to VC exit strategies.

"I've had CFOs say quite frankly that they know a lot more about their companies now," says Marie Lee, manager and tax policy counsel for the American Electronics Association. But more frequently Lee hears that Section 404, which mandates internal controls and audits, is having ruinous consequences for business. "Some companies are saying they're spending three times as much on SOX as they are on health care," says Lee. The act has ended up costing companies far more than the original SEC estimates and is particularly tough on smaller businesses, because the costs add up to a much larger percentage of revenue.

The industry has some hope, though, because the SEC appears to be viewing implementation of SOX as a work in progress. "It's reassuring to hear that the SEC is listening to the misgivings of smaller companies," says Lee. "But we're concerned, because costs for compliance don't appear to be going down in year 2. This is a larger burden than anyone expected."

Cameron Crotty is senior editor of ELECTRONIC BUSINESS.